

Utilization of the Microflora Indigenous to and Present in Oil-Bearing Formations to Selectively Plug the More Porous Zones Thereby Increasing Oil Recovery During Waterflooding -- Class I

Hughes Eastern Corporation

Carter Sandstone

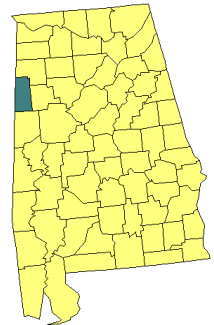
North Blowhorn Creek Field

@ 2,300 ft.

Lamar County, Alabama

Mississippian Age

Black Warrior Basin



DE-FC22-94BC14962

Contract Period:

1/1/1994 to 6/30/1999

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N/A

Objective: Test the ability of indigenous microorganisms to preferentially plug the more porous zones of previously waterswept areas of the Carter sandstone in North Blowhorn Field, Lamar County, Alabama, thereby increasing oil recovery during waterflood.

Technologies Used: Core analysis: microorganism counts, porosity/permeability, core description, SEM, relative permeability; coreflooding. Chemical/microbial and petrophysical analysis completed. Fluid analysis, tracer studies.

Background: This project is designed to test the ability of indigenous microorganisms to preferentially plug the porous zones of previously waterswept areas of the Carter sandstone in North Blowhorn Creek Field, Lamar County, Alabama, thereby increasing oil recovery during waterflood. Incremental production of 0.5 to 1.0 million barrels of oil is possible if the technology is expanded field wide. The project differs from other MEOR projects by using inorganic nitrogen and phosphorus fertilizer (recently an addition of molasses) to stimulate the growth of indigenous microorganisms. The nutrients are injected in carefully controlled concentrations and sequences to preclude overgrowth. Live cores from newly drilled wells were employed to validate the nutrient injection scheme and make any necessary adjustments to ensure maximum efficiency. The efficacy of the process was evaluated by comparison of results to injector producer complexes not receiving nutrient supplementation.

Incremental Production: Incremental production rate is 100 BOPD. As of Dec 1998 69,000 BO had been produced by MEOR.

Expected Benefits and Applications: Low cost process for improving waterflood sweep efficiency. Waterflood sweep improvement by stimulating growth of in-situ microorganisms by nutrient (inorganic nitrogen and phosphorus fertilizers, plus molasses) injection. The concept is designed to test the ability of indigenous microorganisms to preferentially plug the more porous zones of previously waterswept areas of the Carter Sandstone in North Blowhorn Field, Alabama. The potential for application to other reservoirs is high.

Accomplishments: Waterflood fluid diversion in the reservoir through stimulation/growth of in-situ microorganisms. Extended life of reservoir by 5 years with a total increase of 595,000 bbls of oil above natural decline. The 1997 annual report reveals that after 34 months of nutrient supplementation to 10 injection wells for 22 producing wells in the test patterns, 11 show positive response, 9 remain in natural decline and 2 show signs of improvement. Five wells have been drilled and placed on production. The cores indicate that much oil in the reservoir has been bypassed or unswept by historic water-flood. The amount of residual oil in the cores underscores the need for improving conventional water-flood technology in stratified reservoirs. Chemical and microbiological analysis of the live cores recovered in 1994 and 1996 have been completed. The live core flooding tests confirmed that indigenous bacteria in the subject reservoir rock could be stimulated to grow by supplying the bacteria with sufficient amounts of nitrogen and phosphorous. Restriction of flow through the cores was accomplished as predicted, and electron microscopy demonstrated numerous microorganisms in the treated cores. Chemical, microbiological, and petrophysical baseline data on the wells in the test patterns (both control and test) were completed. The test pattern injection wells accepted the nutrient injection for over three years with no noticeable adverse effects on injectivity other than a gradual decline, which may be the result of microbial permeability restriction in the reservoir. Experimental technology; application has not spread to other fields, but has spread within North Blowhorn field. Because of positive results, project was expanded from 4 to 10 test injectors in July 1997. Since then 12 out of 19 producers have responded positively. Waterflood fluid diversion was successful in the reservoir through stimulation/growth of in-situ microorganisms. Project received the 1998 Hart's Award for Best Advanced Recovery Project in the Gulf Coast Section. Operators in fields in several other states are considering implementing the microbial technology as the results of presentations on this project.

Publications: (1) Brown, L. and Vadie, A. A., "The Utilization of the Microflora Indigenous to and Present in Oil-Bearing Formations to Selectively Plug the More Porous Zones Thereby Increasing Oil Recovery During Waterflooding," Annual Report to DOE for period Jan. 1-Dec. 31, 1995. (2) Brown, L.R., Vadie, A. A., Stephens, J. O., and Azadpour, A., "Enhancement of the Sweep Efficiency of Waterflooding Operations by In-Situ Microbial Population of Petroleum Reservoirs," Paper presented at Fifth International Conference on Microbial Enhanced Oil Related Technology for Solving Environmental Problems, Plano, Texas, September 11-14, 1995. (3) Brown, L.R., Vadie, A. A., and Stephens, J. O., "Utilization of Indigenous Microflora in Permeability Profile Modification of Oil-Bearing Formations" SPE 35448, SPE/DOE Improved Oil Recovery Symposium, Tulsa, OK, April 21-24, 1996. (4) "Going Underground to Spy

on MEOR Microbes and Finding Way MEOR Barrels of Incremental Oil" L.R. Brown, A. A. Vadie, and J. O. Stephens; The Class Act Vol. 4/1, Winter, 1998. (5) L.R. Brown, A.A. Vadie, J. O. Stephens, "Slowing Production Decline and Extending the Economic Life of an Oil Field: New MEOR Technology", SPE 59306, SPE 12th Improved Oil Recovery Symposium, Tulsa, OK, April 2-5, 2000.

Recent/Upcoming Technology Transfer Events: (1) Brown, L. "Field Demonstration of the ability of in-situ microorganisms in the oil-bearing formations to modify waterflooding profiles": AAPG Eastern, Lexington, KY, September 28-30, 1997. (2) Lewis Brown, "Using Microorganisms to Improve Oil Recovery" March 13, 1998, Department of Biology, University of Nevada at Las Vegas. (3) Lewis Brown, "Microbial Enhanced Oil Recovery" October 10, 1998, Ann. Meeting Southern Great Lakes Sec. Society of Industrial Microbiology, Michigan State University. (4) Lewis Brown, "Microbial Enhanced Oil Recovery", October 21, 1998, Long Beach, CA Chapter SPE. (5) A workshop, "Microbial enhanced Oil Recovery: North Blowhorn Creek Unit, Black Warrior Basin, Northwest Alabama", Jackson, Mississippi, November 4, 1998. (6) J. O. Stephens, L.R. Brown and A. A. Vadie made presentation on MEOR at Bartlesville, OK SPE meeting on 2/18/99. (7) J. O. Stephens and L.R. Brown made presentations on MEOR at Midland, TX SPE Reservoirs Study Group on 2/11/99. (8) MEOR presentation at PTTC workshop in Morgantown, WV, 3/30/99. (9) MEOR presentation at PTTC workshop Rocky Mountain SPE Section, Gillette, WY, May 1999. (10) Jim Stephens, Lewis Brown and Alex Vadie, "Microbial Enhanced Oil Recovery North Blowhorn Creek Unit": PTTC Workshop, June 3, 1999, Midland, TX. (11) James O. Stephens, "A Low Cost Solution for Enhanced Waterflood Performance", Hughes Eastern Corporation; DOE Oil and Gas Conference, June 28-30, 1999, Dallas Texas. (12) Brown, Lewis, "Enhanced Oil Recovery using Microbial Permeability Profile Modification Technology"; AAPG Pacific/ SPE Western Regional Joint Meeting, Long Beach, CA, June 19-22, 2000.

Project Status: Project complete. Final report published November 1999.